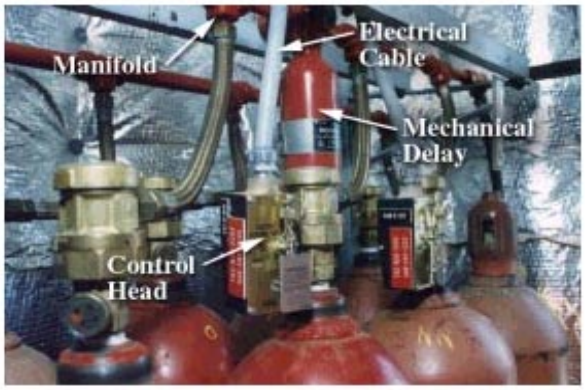
LESSONS LEARNED

INADVERTENT FIRE SUPPRESSION SYSTEM ACTUATION/CO_2 DISCHARGE

EXECUTIVE SUMMARY



On July 28, 1998, at the Idaho National Engineering and Environmental Laboratory (INEEL), during preparation for electrical system preventive maintenance, a high-pressure CO_2 fire suppression system unexpectedly actuated when workers opened the last of several electrical circuit breakers in Building 648 at the Test Reactor Area. The room where workers were located was filled instantly with CO_2, creating whiteout conditions. Within seconds, personnel were struggling to escape the potentially lethal atmosphere in poor visibility and combating the disorienting effects of CO_2. Workers did not have means to safely escape and were deprived of clear exit pathways, emergency breathing apparatus, emergency exit training, exit pathway lighting, and emergency ventilation. The CO_2 discharge occurred without the actuation of an evacuation warning alarm. The accident resulted in one fatality, several life-threatening injuries, and significant risk to the safety of the initial rescuers. A Department of Energy (DOE) Type A Accident Investigation Board determined that this accident was avoidable. This document is intended to provide managers, supervisors, and workers with a brief summary of the causes of this accident, lessons learned following the investigations into the event, risks and consequence of fire suppression system actuation, and recommendations for preventing similar or related events.

KEY ACCIDENT FACTORS

- Inadequate Work Planning and Control
  - Hazard analysis did not address CO_2 Hazard
  - System not physically locked out
  - Electronic impairment insufficient to protect personnel
- Deficient System Design
  - Predischarge alarm devices deleted from design
  - No positive lockout device installed as per OSHA
- Inadequate Worker Safety Controls and Emergency Preparedness for Accidental CO_2 Discharge
  - Emergency breathing apparatus not readily available
  - Emergency exit pathways not clear or illuminated
  - No training on CO_2 hazards; search and rescue training discontinued
- Failure to flowdown and institutionalize worker protection requirements

CAUSAL FACTORS

The DOE Type A Accident Investigation Board reported the following root causes and contributing causes to this accident:

Direct Cause

Inadvertent activation of electric control heads that initiated the unexpected release of CO_2 in an occupied space without a pre- discharge warning alarm.

Root Causes

- A systematic method for identifying, institutionalizing, or implementing requirements for the design, installation, and work conducted on or affected by the CO_2 fire suppression system did not exist.
- Unstructured work controls in place at INEEL contributed to increased safety risks to workers.

Contributing Causes

- Faulty design and installation of the fire suppression system, due to failure to implement appropriate requirements and procedures; failure to install monitoring or feedback circuit for CO_2 discharge header or solenoid valve position signal to the discharge alarm.
- Failure to use physical (lockout/tagout) and administrative barriers (current procedures and work planning and control processes that implemented regulatory requirements).
- Competency of staff at all levels to deal with CO_2 hazards was not assured.
- Corrective actions were not taken and lessons learned were not applied from previous accident investigations, particularly in work planning and control.
- Failures to identify, institutionalize, and implement requirements for immediate emergency rescue and response to planned and unplanned CO_2 discharges.

LESSONS LEARNED

- The need for CO_2 fire suppression systems should be reevaluated for risk versus benefit as facility missions, inventory, and life cycle status change.
- Electrical power transients can inadvertently activate output or releasing circuits in microprocessor-based fire panels.
- Disabling SW circuits does not physically disable this CO_2 fire suppression system.
- CO_2 systems must have monitor or feedback circuit from header pressure to alarm panel.
- CO_2 suppression systems must have a positive isolation device for lockout and personnel protection.
- If facilities with flood CO_2 fire suppression systems are to be occupied with the system active, preparations must be made for emergency egress and for immediate search and rescue.
- Personnel working around or near CO_2 systems must first be trained on requirements, hazards, alarms, and emergency response.

RECOMMENDED WORKER PROTECTION ACTIONS

- Ensure pressurized CO_2 Fire Suppression Systems incorporate a positive isolation device capable of being locked out.
- Ensure CO_2 Fire Suppression Systems are properly designed, installed, and tested. Testing should include monitoring or feedback circuits, 30-second pre-discharge warnings, and 25-second mechanical delay.
- Ensure emergency action plans are developed and implemented for occupied CO_2-protected spaces. These plans should include provisions for training, posting of warning signs and instructions, clear exit pathways, emergency ventilation, exit lighting, and emergency breathing apparatuses.
- Ensure CO_2 hazards are identified and controlled when personnel are planning work activities near CO_2 Fire Suppression Systems or CO_2 Protected Spaces.

REQUIREMENTS FOR PROTECTING WORKERS

The following DOE orders, federal regulations, and codes contain requirements associated with protecting workers from the hazards associated with CO_2 fire-extinguishing systems:

DOE Orders 5480.4 and 5480.7A
29 CFR1910, Subpart E 29 CFR1910, Subpart J
29 CFR1910, Subpart L
29 CFR1910.1200, Appendix E
NFPA 12, Sections 1 through 5

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